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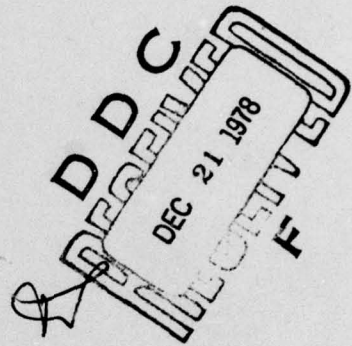FILMED
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Integral Reflection Coefficients, R, for Curved and Ground LiF and ADP

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X-Ray Optics Branch
Radiation Technology Division

November 29, 1978

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Integral reflection coefficients, R, were measured for flat and curved crystals of LiF and ADP to determine whether or not curving degraded their diffracting power. There was, in fact, an increase in measured R values for the curved crystals except for 2nd order diffraction of Cr radiation from ADP which decreased by 10%. Theoretical R values were calculated for all of the experimental situations and showed good agreement on an absolute as well as a relative basis.

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INTEGRAL REFLECTION COEFFICIENTS, R,
FOR CURVED AND GROUND LiF AND ADP

INTRODUCTION

The objective of the work was to demonstrate that
curved and ground crystals of LiF (200) and ADP (101) can
be prepared without degrading the integral reflection co-
efficient, R, (diffracting efficiency) compared to flat
crystals.

MATERIAL PREPARATION
MEASUREMENTS, AND CALCULATIONS

LiF

Blanks 1 × 5 cm by 0.15 cm thick were cleaved from
Harshaw material. Fig. 1a illustrates a topograph of the
as-cleaved material. The R values at Cu Kα for the cleaved
material were measured on the parallel-beam optics already
described (1). R ranges from 3.57×10^{-5} to 5.26×10^{-5}
which is typical of good LiF (2).

Next, one of the blanks ($R = 3.57 \times 10^{-5}$) was curved
plastically to 40 cm radius and then ground to 20 cm radius.
Fig. 1b is a topograph of the curved and ground crystal.
There are some variations in diffracted intensity in Fig. 1b
but no apparent flaws or misoriented regions.

Note: Manuscript submitted October 13, 1978.

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Fig. 2a and b show the focusing of the crystal at crossover. Fig. 2a is with the crystal set at the maximum intensity for 1st order diffraction of Cu Kα radiation. It shows resolution of the $K\alpha_1$, $K\alpha_2$ doublet indicating accurate curving and grinding. In Fig. 2b the crystal was rocked over a range of 4 degrees 2θ during exposure. It still shows the $K\alpha_1$, $K\alpha_2$ separation and is a further indication that there are no misoriented regions in the crystal, i.e. that the curving and grinding are accurate.

Finally the curved-crystal R value was measured with a divergent-beam focusing geometry. This R value was 8.42×10^{-4} which cannot be compared with the flat cleaved-crystal value because the plastically curved crystal is mosaic. It does fall satisfactorily within the calculated range of curved-crystal R values, i.e. 3.5×10^{-4} for minimum imperfection and 9.8×10^{-4} for ideally mosaic.

ADP

A boule of ADP was sawed into blanks the same size as for LiF. Fig. 3a shows a topograph of one of the blanks and again, as for the LiF, it indicates uniform diffraction. R values for the flat ADP at Cr Kα were 6.78×10^{-5} for the as-sawed material and 5.7×10^{-5} for a blank after some waster polishing. (A calculated value for perfect ADP is 3×10^{-5}.)

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ADP is a very fragile material mechanically and also is sensitive to thermal shock. Details of the preparation of a curved and ground ADP will not be discussed except to say that the curving is elastic. Fig. 3b is a topograph (3rd order of Cu Kα) of the curved and ground ADP. There is one darker line which corresponds to a visible crack in the crystal but the intensity is uniform except for that.

Fig. 4a and b show the crossover of the diffracted radiation (again 3rd order Cu Kα) and should be compared to Fig. 2a and b for LiF. The resolution of ADP is slightly better than for LiF as would be expected because the elastically curved ADP corresponds to an essentially perfect crystal whereas the LiF is mosaic due to plastic dislocations.

The R value for the curved ADP was measured in two ways. First, it was measured in a region about 1×1 cm by rocking the crystal through the diffracting angle on the parallel-beam optics used for measuring flat crystals (1st order Cr Kα). This R value was 7.01×10^{-5} compared to 6.38×10^{-5} for the flat as-sawed blank and to 9.6×10^{-5} calculated for curved ADP. Second, the R value was measured with a divergent beam in focusing geometry but with 2nd order Cr Kα. It was necessary to go to 2nd order diffraction for the divergent beam measurement because of the larger d-spacing compared to LiF and the geometry of the divergent-beam apparatus. The curved and ground R value for 2nd order Cr Kα was 1.18×10^{-5}. To compare this with a flat crystal

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it was necessary to remeasure a flat as-sawed blank in the
2nd order diffraction; this gave a value of 1.28×10^{-5}
which compares satisfactorily with the curved crystal R
value and with a calculated R value of 1.6×10^{-5} for the
2nd order diffraction.

CONCLUSIONS

All of the measurements and calculations for curved
and ground LiF and ADP indicate that there is no degradation
of flat-crystal R values if the crystal preparation is
carried out properly. Table I summarizes comparative R
values.

In addition the measurements indicate that there is no
degradation of resolution for properly curved and ground
crystals. This was demonstrated by the separation of the
$K\alpha_1$, $K\alpha_2$ doublet with the curved and ground crystals (1st
order Cu Kα for LiF and 3rd order Cu Kα for ADP).

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REFERENCES

(1) J. V. Gilfrich, D. B. Brown, P. G. Burkhalter, Appl. Spectros. $\underline{29}$, 322 (1975).

TABLE I. R-Values for LiF and ADP

		Measured	Calculated
LiF (200)	flat, cleaved	3.6×10^{-5}	3.4×10^{-5}
Cu Kα	curved, abraded	8.0×10^{-4}	3.5×10^{-4}
			minimum imperfection
			9.8×10^{-4}
			ideally mosaic
ADP	(101) flat	6.8×10^{-5}	6.2×10^{-5}
Cr Kα	curved	7.0×10^{-5}	9.3×10^{-5}
	(202) flat	1.3×10^{-5}	1.3×10^{-5}
	curved	1.2×10^{-5}	1.6×10^{-5}

LiF

(a)

(b)
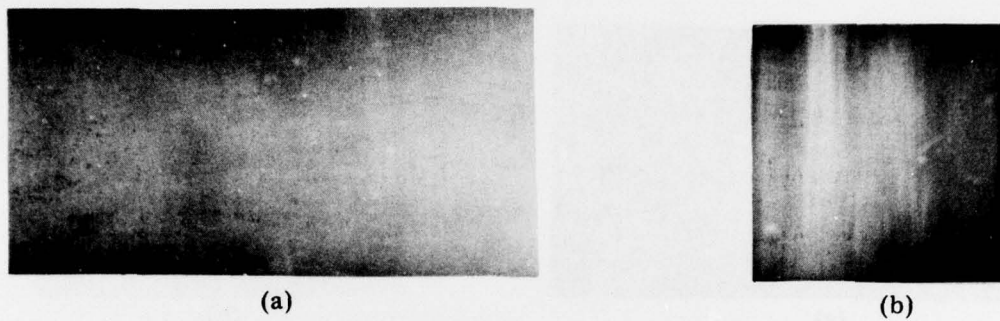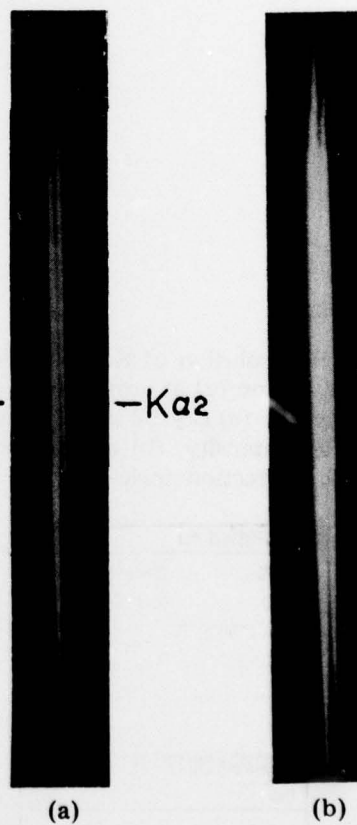
Fig. 1 — (a) Topograph of cleaved, flat LiF crystal; Cu Kα, 1st order,
(b) topograph of curved and ground LiF crystal, Cu Kα, 1st order

Fig. 2 — Resolution of Kα$_1$ Kα$_2$ doublet
(Cu Kα, 1st order) at crossover of curved
LiF crystal. (a) Crystal set for maximum
diffracted intensity, (b) crystal rocked
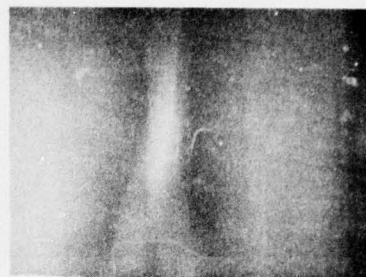through diffraction angle.

Kα$_1$—   —Kα$_2$

(a)   (b)

(a)   (b)

Fig. 3 — (a) Topograph of sawed, flat ADP crystal; Cu Kα, 3rd order,
(b) topograph of curved and ground ADP crystal; Cu Kα, 3rd order

Fig. 4 — Resolution of $K\alpha_1$ $K\alpha_2$ doublet
(Cu Kα, 3rd order) at crossover of curved
ADP crystal. (a) Crystal set for maximum
diffracted intensity, (b) crystal rocked
through diffraction angle.

$K\alpha_1$—   —$K\alpha_2$

(a)   (b)